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A High-Temperature Combination Sonic Aspirated Thermocouple and Total-Pressure Probe

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A sonic-aspirated platinum rhodium - platinum thermocouple was built to extend the range of the chromel-alumel types reported in (1)[2] and (2) and to be used in a survey apparatus for combustor research (3). The advantage of this type of thermocouple probe is that it is sensibly free of radiation and conduction errors, and the total temperature of the gas is obtained by applying a constant correction factor for recovery.

The present design incorporates a removable insert, with the thermocouple and nozzle as an integral unit of the insert. This feature fixes the position of the junction in the throat of the nozzle and therefore has an advantage over previous designs in which the nozzle was attached to the main body and differential thermal expansion caused uncertainties in relative junction-to-nozzle throat positioning. The insert is enclosed in a main assembly consisting of a 3/8-inch O.D., water-cooled, inconel supporting tube with a platinum-rhodium tube at the sensing end. The head also contains a total-pressure tube to take simultaneous pressure readings. Details of the sensing end of the probe are shown in Fig. 1.

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[2]Numbers in parentheses indicate References at end of paper.

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The probe was tested in a high-temperature tunnel, described in (4), through a temperature range from 2100° to 3550° R, a free-stream Mach number range of 0.4 to 0.6, and at a static pressure of 1 atmosphere. A platinum rhodium - platinum, bare-wire, crossflow probe was used as a comparison instrument. The tests were performed by moving each probe, in turn, to the same location in the test section while tunnel conditions were held constant.

Total temperature T_t for the bare-wire, crossflow probe was obtained by applying recovery, radiation, and conduction corrections to the indicated temperature $T_{ind.}$ as reported in (5). The total temperature of the aspirated probe was obtained by applying a constant recovery correction of $1\frac{1}{2}$ per cent, where $T_t = T_{ind.} \times 1.015$. This correction was obtained from a calibration at room temperature.

The results of the high-temperature tests are shown in Fig. 2, which is a plot of the deviation from the mean temperature as measured by both pyrometers throughout the temperature range. The agreement is in a band whose limits are on the order of 1 per cent and whose probable error is 0.5 per cent.

REFERENCES

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4 "Some Effects of Exposure to Exhaust-Gas Streams on Emmittance and Thermoelectric Power of Bare-Wire Platinum Rhodium-Platinum Thermocouples," by G. E. Glawe and C. E. Shepard. NACA TN 3253, August 1954.

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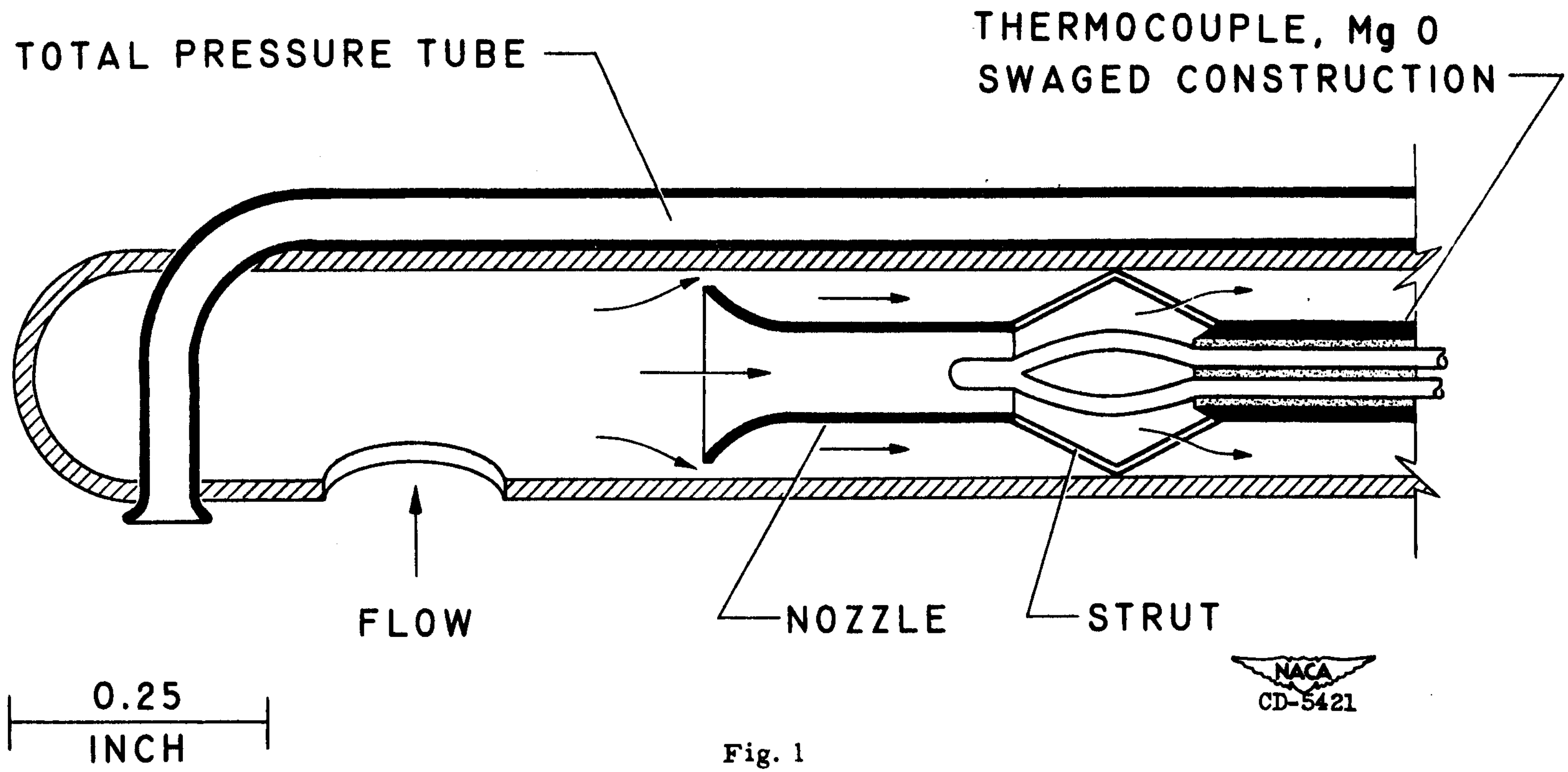
TOTAL PRESSURE TUBE
THERMOCOUPLE, Mg O
SWAGED CONSTRUCTION
FLOW
NOZZLE
STRUT
0.25
INCH
NACA
CD-5421

Fig. 1

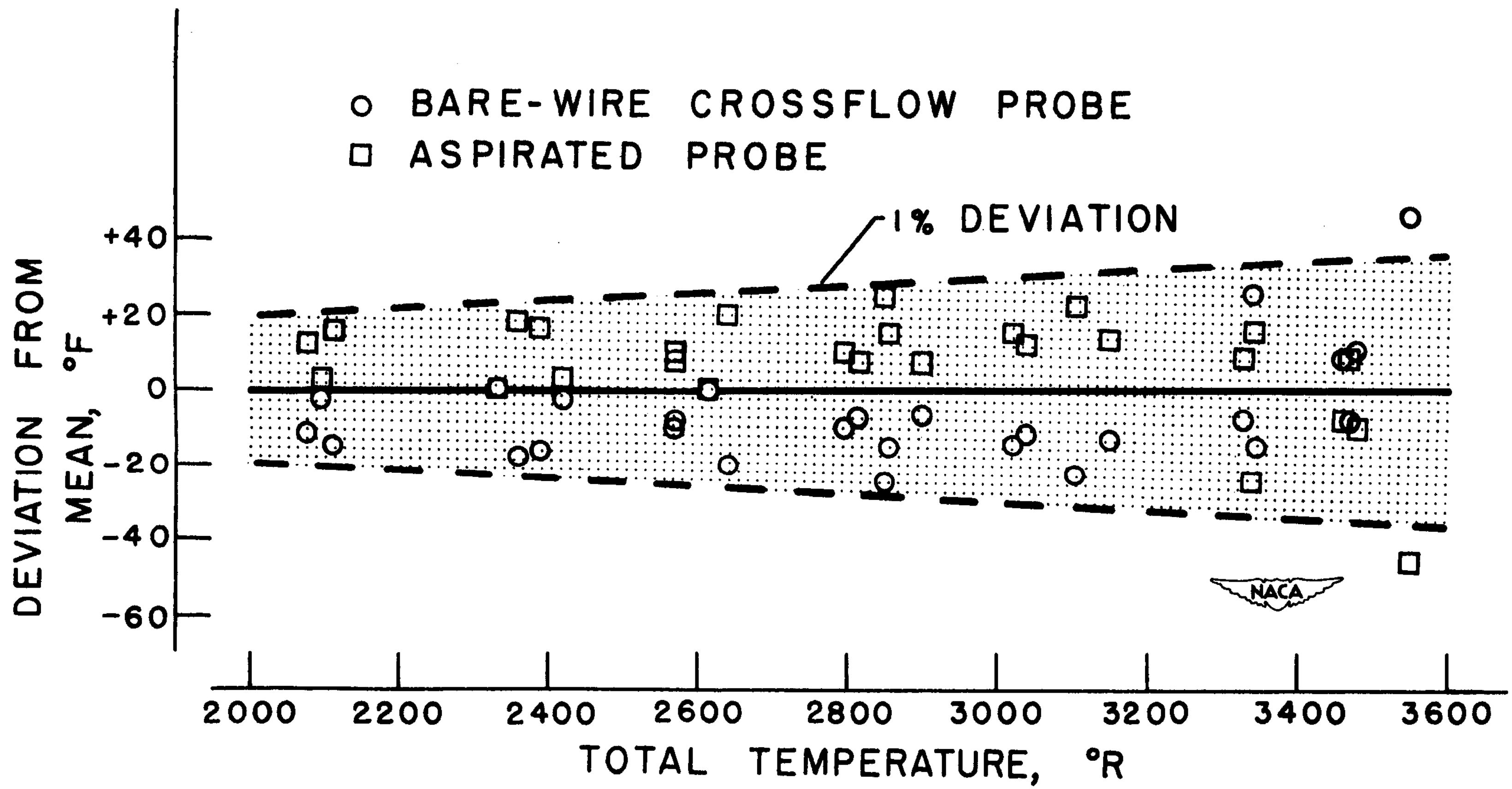

Fig. 2 Comparison of bare-wire crossflow and aspirated water-cooled high-temperature probes at static pressure of 1 atmosphere and Mach numbers of 0.4 to 0.6.